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NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS COX
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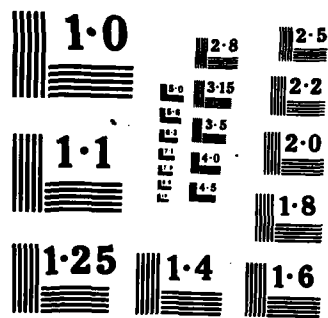
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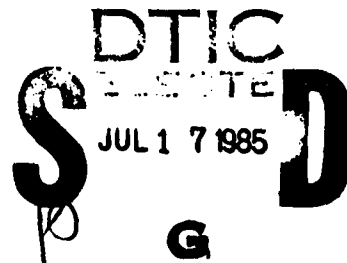


AD-A157 292

CONNECTICUT RIVER BASIN
WOODSTOCK, VERMONT

COX DISTRICT RESERVOIR DAM
VT 00234

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

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OCTOBER 1979

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) → The dam is an earthen embankment structure with an overall length of 145 ft. with a maximum height of 20 ft. The dam is in poor condition. It is small in size with a significant hazard potential. There are various remedial measures and recommendations which should be undertaken by the owner.		



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF
NEDED

MAR 06 1980

Honorable Richard A. Snelling
Governor of the State of Vermont
State Capitol
Montpelier, Vermont 05602

Dear Governor Snelling:

Inclosed is a copy of the Cox District Reservoir Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Water Resources, the cooperating agency for the State of Vermont. In addition, a copy of the report has also been furnished the owner, Woodstock Aqueduct Company, Woodstock, Vermont.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Water Resources for your cooperation in carrying out this program.

Sincerely,

A handwritten signature in dark ink, appearing to read "Max B. Scheider".

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

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COX DISTRICT RESERVOIR DAM

VT 00234

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CONNECTICUT RIVER BASIN
WOODSTOCK, VERMONT



PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

LETTER OF TRANSMITTAL
FROM THE CORPS OF ENGINEERS TO THE STATE
TO BE SUPPLIED BY THE CORPS OF ENGINEERS

NATIONAL DAM INSPECTION PROGRAM
PHASE I - INSPECTION REPORT
BRIEF ASSESSMENT

Identification No.: 00234
Name of Dam: Cox District Reservoir Dam
Town: Woodstock
County and State: Windsor, Vermont
Stream: Tributary to Ottauquechee River
Date of Inspection: September 12, 1979

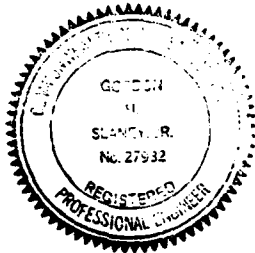
Cox District Reservoir Dam is an earthen embankment structure with an overall length of 145 feet including the spillway section. Maximum height of the dam as measured from the dam crest to the streambed is 20 feet. Top width is 10 feet and the upstream embankment is estimated to be on a 2 1/2 horizontal to 1 vertical slope and the downstream embankment is on a 3 to 1 slope. The spillway is located at the left abutment and has a waterway opening 7.75 feet wide which can be controlled with stoplogs. There is a gated 8 inch diameter outlet pipe which is tied into a water supply system on an emergency basis. The dam was constructed about 1930.

Visual inspection indicated that the dam is in poor condition. The inspection revealed significant seepage under the downstream portion of the spillway section, dense vegetation on the downstream face of the dam including large trees and cracks in the slab and walls of the downstream portion of the spillway.

Based on a maximum storage of 21 acre-feet and a maximum height of 20 feet, Cox District Reservoir falls within the small size classification. The dam's hazard classification has been established as significant based on potential flooding of two dwellings. Based on the small size of the dam and its significant hazard classification and in accordance with Corps of Engineers Guidelines, the test flood inflow should be of a magnitude ranging from the 100 year frequency flood to 1/2 the Probable Maximum Flood (PMF). The 100 year frequency flood was used for the test flood inflow, which is 550 cfs. The routed test flood outflow of 530 cfs overtops the dam by approximately 0.6 feet. With the water surface at the top of the dam, the spillway capacity is approximately 260 cfs (about 49 percent of the routed test flood outflow).

It is recommended that the owner remove the spillway stoplogs, and engage a qualified registered professional engineer to (1) investigate the cause and effect of the seepage beneath the spillway structure and to design remedial measures to prevent uncontrolled seepage in this area; (2) design an acceptable means of removing the trees and their roots from the dam and backfilling the voids with appropriate material; (3) determine what the dam is constructed of and if the concrete wall existing on the upstream slope is a core wall which extends into the foundation; and (4) investigate spillway adequacy and consider any modifications, if necessary. Remedial measures include the removal of brush from the downstream face of the dam, and establishment of a downstream warning system.

The recommendations and remedial measures are described in Section 7 and should be addressed within 1 year after receipt of this Phase I Inspection Report by the owner.



Gordon H. Slaney, Jr.
Gordon H. Slaney, Jr., P.E.
Project Engineer

HOWARD NEEDLES TAMMEN & BERGENDOFF
Boston, Massachusetts

This Phase I Inspection Report on Cox District Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Richard J. DiBuono

RICHARD DIBUONO, MEMBER
Water Control Branch
Engineering Division

Aramast Mahtesian

ARAMAST MAHTESIAN, MEMBER
Foundation & Materials Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, CHAIRMAN
Design Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might be otherwise detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test-Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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(b) Dense vegetation on the embankment makes it impossible to adequately examine the downstream slope. In view of the seepage near the spillway, this is a particularly poor condition.

The dense vegetation prevents adequate inspection to determine if seepage or wet areas exist on other areas of the downstream slope.

(c) Large trees with large root systems are growing on the downstream slope of the embankment. In one case, a 2 foot diameter tree with a large visible root system is growing on the slope within 6 feet of the spillway structure.

(d) Several cracks were observed in the "U" section of spillway on the downstream face of the dam.

(e) There is no means for dewatering the reservoir.

(f) Gate for 8 inch diameter pipe is located on the downstream side of the dam, thus keeping the pipe through the dam under continual pressure.

The spillway structure and spillway channel consists of a concrete slab and training walls, and a u-type structure as shown in Section F-F, Figure 2 of 2, Appendix B, and in Photos No. 11, 12 and 13. The spillway flow is controlled by the stoplogs, which are located in horizontal portion of the spillway, see Photo No. 10.

As discussed previously, there is a significant flow of water emerging from beneath the spillway structure onto the downstream slope. There is also water emerging from beneath the spillway below the downstream end of the structure. These observations indicated that a significant volume of water is flowing between the spillway structure and the embankment. There is also considerable concrete deterioration in the form of the cracks (walls and slab) and spalling. For the location of major cracks see the Plan of Spillway, Figure 1 of 2 in Appendix B. Visual inspection of the spillway structure indicates that it is in poor condition. In addition, leakage was occurring through the spillway stoplogs.

The pond is outleted by an 8 inch diameter pipe which is controlled by a valve. The valve is located at the toe of the dam in a concrete chamber set into the downstream face of the dam. The drain pipe and the controls appeared to be in good condition.

There is no permanent structure for access over the spillway section. The 2x10 inch wooden planks shown in Photo No. 3 provide a makeshift means of providing access to the crest of the dam as they are not anchored and are in poor condition.

d. Reservoir Area. The reservoir area is only 1.53 acres in extent. The banks are wooded with small trees overhanging the pond. There are no dwellings on the shoreline.

e. Downstream Channel. The spillway discharges to a natural channel. The channel is about 5 feet wide, see Photos No. 16 and 18, and is in a wooded valley section about 30 feet wide with steeply sloping sides.

3.2 Evaluation

Visual examination indicates that the dam is in poor condition. Visual examination revealed the following:

(a) Significant seepage is exiting onto the downstream face from beneath the spillway structure. Seepage from beneath the spillway is also exiting in the discharge channel 2 feet below the end of the structure.

Downstream Slope

The downstream slope of the embankment is covered with dense vegetation which includes brush and trees up to 2 1/2 feet in diameter. Photo No. 4 shows the downstream slope viewed from a point midway between the crest and the toe looking towards the right abutment. Note the matted brush making inspection of the slope impossible in some areas. Photo No. 5 shows the downstream toe viewed from the spillway channel toward the right abutment.

Photo No. 8 shows a large tree and its extensive root system on the downstream slope located about 6 feet from the spillway training wall which is shown in the background of the photo. Photos No. 6 and 7 also show large trees growing on the downstream face. The tree in Photo No. 7 is a dead elm tree.

Photo No. 14 shows a significant flow of water emerging onto the downstream slope from beneath the spillway structure. This seep is located about 10 feet above the toe of the embankment.

An inspection report dated April 16, 1952 states that there was seepage along the outside of the chute spillway.

Dye was injected into a construction joint at the top of the spillway to determine if the water seen exiting on the slope was entering this joint and flowing beneath the spillway slab. The joint, which separates the horizontal portion of the spillway on the dam crest from the sloping portion on the downstream face is shown in Photo No. 15.

One minute and twenty seconds after the dye was injected at the joint, it emerged at the location shown in Photo No. 14. The distance from the injection point to the seep is about 33 feet.

In addition to emerging at the seep location on the slope, the dye also emerged from the spillway channel below the floor slab. Photo No. 16 shows the dye emerging from the center of the channel below the concrete spillway structure.

c. Appurtenant Structures. Visual inspection of the concrete spillway and concrete spillway channel revealed that the concrete surface of the spillway structure has experienced considerable deterioration in the form of cracks (walls and slab) and spalling (walls). There is also a significant flow of water beneath the spillway structure and between the spillway structure and the embankment. Visual inspection of the spillway structure indicates that it is in poor condition.

SECTION 3 VISUAL INSPECTION

3.1 Findings

a. General. The field inspection of Cox District Reservoir Dam was made on September 12, 1979. The inspection team consisted of personnel from Howard, Needles, Tammen & Bergendoff and Geotechnical Engineers, Inc. A representative of the owner was also present during the inspection. Inspection checklists, completed during the inspection, are included in Appendix A. At the time of inspection, the water level was approximately 4.1 feet below the crest of the dam. The upstream face of the dam could only be inspected above this level.

b. Dam. Visual inspection of the dam indicated that it is in poor condition.

The dam is an earth embankment about 145 feet long. The height of the dam is given as about 20 feet. No sketches or plans and specifications describing the dam existed at the time of inspection. A concrete spillway structure passes through the upper part of the embankment between the left abutment and the embankment. The concrete discharge channel of the spillway sits on the downstream slope of the embankment.

Upstream Slope

Approximately 4 feet of the upstream slope of the dam is visible above the water line and is shown in Photo No. 1. A concrete wall extends the entire length of the dam on the upstream slope. A wall is just discernible in Photo No. 1 and is shown more clearly in Photo No. 2. The wall height above the slope varies between 1 and 2 feet. The depth and purpose of the wall is not known.

Crest

The crest of the dam, which is 10 feet wide, is covered with dense vegetation. Photo No. 3 shows the crest viewed from the left abutment. The wood planks in the foreground of the photo span the concrete spillway structure.

Vegetation on the crest is so dense that the embankment surface could not be inspected adequately.

SECTION 2 ENGINEERING DATA

2.1 Design

No original design data were disclosed for Cox District Reservoir Dam. The dam was constructed circa. 1930 and the spillway construction is dated 1936. It is possible the spillway is a more recent addition to the dam. Some grading was done near the left dam abutment in 1952 and the pond drain valve and outlet were covered at that time. It was reported that the reservoir may have been slightly enlarged at that time.

2.2 Construction

No construction records are available for use in evaluating the dam.

2.3 Operation

No engineering operational data were disclosed.

2.4 Evaluation

a. Availability. There is no design engineering data available for this dam. One inspection report dated 1952 is on file at the Vermont Department of Water Resources, Water Quality Division, Montpelier, Vermont 05602.

b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Validity. Since no original plans of this dam are available the information shown in this report is based solely on the results of the visual inspection.

i. Spillway

(1) Type - concrete slab and walls with wingwalls which outlet to a concrete sliceway on the downstream face of the dam.

(2) Length of Weir - 7.75 feet

(3) Crest Elevation - 967.0

(4) Gates - Stoplogs

(5) Upstream Channel - none

(6) Downstream Channel - The concrete spillway chute discharges to a natural stream channel. The channel is about 5 feet wide and is in a heavily wooded valley section which is about 30 feet wide with steeply sloping sides.

j. Regulating Outlets. The reservoir level is maintained by stoplogs which are placed at the spillway entrance where the spillway and wingwalls meet. Invert of the outlet is at elevation 967.0. The stoplogs can be placed to elevation 970.0. Maximum discharge through the section is 260 cfs without the stoplogs. The intake elevation of the 8 inch outlet pipe is unknown. The pipe is at about elevation 950 where the 8 inch gate valve is located. Maximum possible discharge through this pipe is 3 cfs.

e. Storage (gross acre-feet)

- (1) Normal Pool - 18.4
- (2) Flood Control Pool - N/A
- (3) Permanent Spillway Crest Pool - 14.0
- (4) Top of Dam - 21.1

f. Reservoir Surface (acres)

- (1) Normal Pool - 1.53
- (2) Flood Control Pool - N/A
- (3) Spillway Crest - 1.5
- (4) Test Flood Pool - 1.53
- (5) Top Dam - 1.53

g. Dam

- (1) Type - earth
- (2) Length - 145 feet
- (3) Height - 20 feet
- (4) Top Width - 10.0 feet
- (5) Side Slopes - upstream-2 1/2 horizontal to 1 vertical downstream-3:1
- (6) Zoning - unknown
- (7) Impervious core - unknown
- (8) Cutoff - unknown
- (9) Grout Curtain - unknown
- (10) Other - unknown

h. Diversion and Regulating Tunnel

See Section j below.

downstream of the dam with 8 inch gate valves. The invert of the intake is unknown, but is estimated that the pipe is at elevation 950, under the dam. Discharge through this pipe with the water level at normal pool elevation 970 would be 3 cfs. No information is available regarding the pond drain pipe which is now buried. The spillway is set at elevation 967.0 and has a waterway opening of 7.75 feet and a height of 4.9 feet. With no stoplogs in place the maximum discharge, with the water surface at the top of dam (elevation 971.9), is 260 cfs.

(2) It is reported that in June of 1973 the water level did not reach the top of dam but was 3 feet deep at the spillway which would correspond to a discharge of 125 cfs. The stoplogs were removed during this event.

(3) The spillway capacity with the water surface at the top of dam, elevation 971.9 is 260 cfs.

(4) The spillway capacity with the water surface at the test flood elevation of 972.5 would be about 310 cfs.

(5) The total project discharge at the test flood elevation of 972.5 is approximately 530 cfs.

c. Elevation (feet above NGVD)

- (1) Streambed at centerline of dam - 951.9
- (2) Maximum tailwater - unknown
- (3) Upstream invert of outlet works - unknown
- (4) Normal Pool - 970.0
- (5) Full flood control pool - N/A
- (6) Spillway crest (permanent spillway) - 967.0
- (7) Design surcharge - unknown
- (8) Top Dam - 971.9
- (9) Test Flood Surcharge - 972.5

d. Reservoir (miles)

- (1) Length of Maximum Pool - unknown
- (2) Length of Normal Pool - 0.08
- (3) Length of Flood Control Pool - N/A

streambed. The dwellings would be flooded by 3 to 4 feet. This level may endanger a few lives.

e. Ownership. This dam is owned by the Woodstock Aqueduct Company, Woodstock, Vermont 05091.

f. Operator. This dam is operated by the Woodstock Aqueduct Company, Woodstock, Vermont 05091, Mr. Avery Colston operator, Telephone No. 802/457-3040.

g. Purpose of Dam. The dam was constructed to provide storage for water supply for the town of Woodstock. At this time the water is used only as an emergency supply via the 8 inch outlet pipe.

h. Design and Construction History. It was reported that the dam was constructed circa 1930. The concrete spillway section was constructed in 1936. In 1950 some grading was done near the left abutment and fill was added to the downstream valley section on the left side. It was reported that the reservoir may have been slightly enlarged at this time, also the valve and outlet of the pond drain pipe were probably buried during this work.

i. Normal Operating Procedures. Normal water level is maintained by stoplogs which are left in place throughout the year. The stoplogs are removed only during periods of high water caused by heavy runoff. The 8 inch gate valve at the dam is normally open. However, the 8 inch outlet line can be controlled by another valve downstream at the filter plant which is usually closed.

1.3 Pertinent Data

a. Drainage Area. The area tributary to Cox Reservoir consists of 1.08 square miles of wooded mountainous terrain. There are very few dwellings in the watershed. Vondell Reservoir is located 4700 feet upstream of Cox Reservoir and 60 percent of the drainage area is tributary to it. Maximum elevation is at 1700 feet NGVD, and the basin divide consists of additional peaks at 1300 to 1400 feet NGVD. The Normal pool elevation of Cox Reservoir is at elevation 970.

The reservoir surface area is small, being only 1.53 acres. The reservoir banks are wooded with small trees overhanging the pond. There are no dwellings on the shoreline.

b. Discharge at Dam Site.

(1) The outlet works for Cox Reservoir Dam consists of an 8 inch diameter pipe, which is gated at the dam and at a point

dam is 145 feet. The maximum height is 20 feet as measured from the streambed to the top of dam. There is no information regarding the fill zones or any core wall. At the crest, the top width is about 10 feet. The embankment slope on the upstream face is estimated to be on a 2 1/2 horizontal to 1 vertical slope, the downstream embankment slope is 3 horizontal to 1 vertical. Along the upstream face of the dam there is a concrete wall about one foot thick. The top of the wall is about equal to the dam crest. The exposed portion of the wall is vertical and about 2 feet high, with the bottom of the exposed wall at the water level at the time of inspection. It is not known how deep this wall extends. The wall extends from the right side of the spillway to the right abutment.

The spillway is located on the left side of the dam and consists of a concrete waterway opening 7.75 feet wide and 4.9 feet high with shelved wingwalls. Stop logs can be placed in this section to control the reservoir level. This structure discharges to a chute constructed on the downstream face of the dam which has walls 2.5 feet high and varies in width from 7.75 feet to 7.0 feet.

The pond is outleted by an 8 inch diameter pipe which is gated at the toe of the dam. It is estimated that the invert of the pipe under the dam is at elevation 950. The intake elevation is unknown. Access to the gate valve, which is located under the dam, is through a 12 foot long crawl tunnel. This line is also valved about 5,000 feet downstream at the filter plant. The gate at the filter plant is normally closed and the gate at the dam open. No water is taken from the reservoir except in emergencies. It was reported that there was a pond drain pipe in addition to the 8 inch pipe noted above. However, the location of the valve and the pipe inlet and outlet are unknown.

Figures 1 and 2 located in Appendix B, show a plan of the dam and its appurtenant structures. Photographs of each structure are shown in Appendix C.

c. Size Classification. Small (hydraulic height-20 feet, storage-21.1 acre-feet) classification based on the hydraulic height being less than 40 feet and the storage being less than 1000 acre-feet as given in Recommended Guidelines for Safety Inspection of dams.

d. Hazard Classification. The potential for damage posed by this dam is classified as significant. Failure of the dam with the water surface at the top of dam would result in a flood wave about 9 feet high through a reach extending 3800 feet downstream of the dam. Two dwellings located at the end of the reach would be flooded as they are set 4 to 5 feet above the

NATIONAL DAM INSPECTION PROGRAM
PHASE I INSPECTION REPORT
COX DISTRICT RESERVOIR DAM

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Howard, Needles, Tammen & Bergendoff has been retained by the New England Division to inspect and report on selected dams in the State of Vermont. Authorization and notice to proceed were issued to Howard, Needles, Tammen & Bergendoff under a letter of August 24, 1979 from John P. Chandler, Colonel, Corps of Engineers. Contract No. DACW33-79-C-0060 has been assigned by the Corps of Engineers for this work.

b. Purpose

(1) To perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

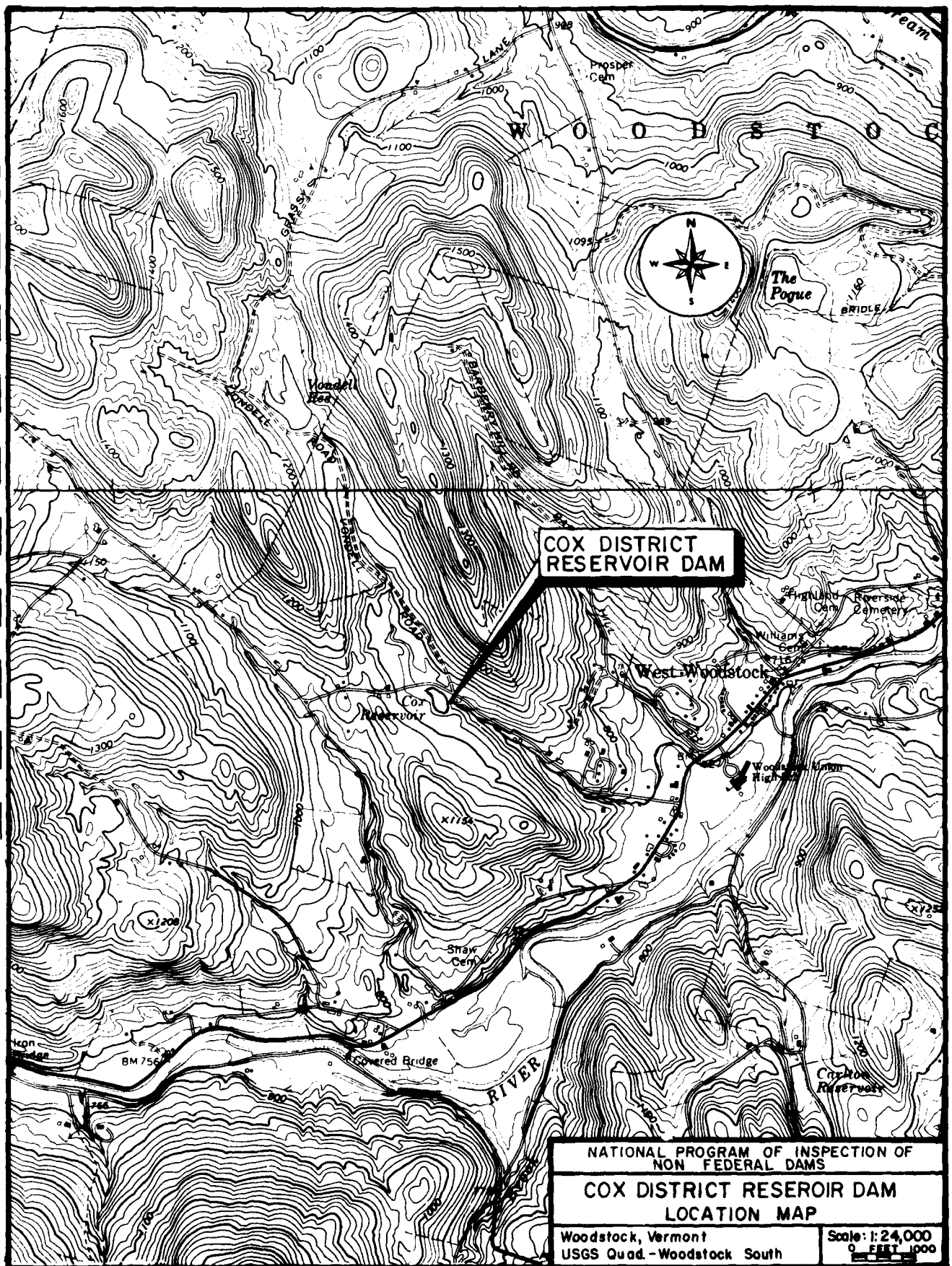
(2) To encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.

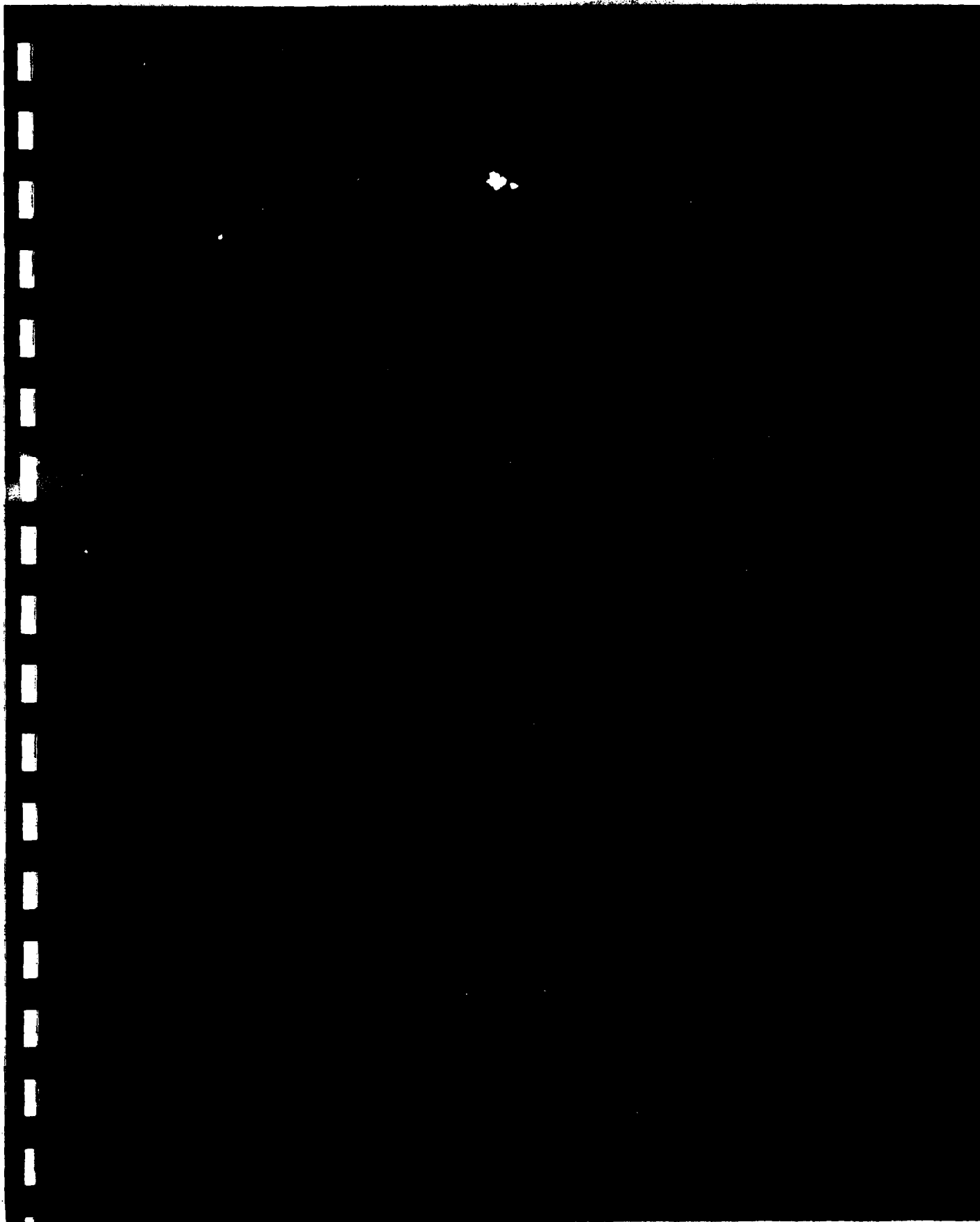
(3) To update, verify and complete the National Inventory of Dams.

1.2 Description of Project

a. Location. Cox District Reservoir Dam is located on a tributary to the Ottauquechee River about one mile upstream of Route 4 in the Town of Woodstock Vermont. The dam is shown on U.S.G.S. Quadrangle Woodstock South, Vermont with approximate coordinates N43°37'00" E72°33'48" Windsor County Vermont. The location of the dam is shown on the preceeding page.

b. Description of Dam and Appurtenances. Cox Reservoir Dam is an earth embankment structure. The overall length of the





Cox District Reservoir Dam - Overview looking downstream.

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APPENDIXES

APPENDIX A - INSPECTION CHECKLIST

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SECTION 4 OPERATIONAL PROCEDURES

4.1 Procedure

Cox District Reservoir Dam is used for an emergency water supply for the Town of Woodstock. Water would be released only under emergency conditions. The 8 inch outlet pipe is gated at the dam and the gate is normally open. The outlet pipe is usually controlled by another valve located downstream which is usually closed.

4.2 Maintenance of Dam

There is no regular maintenance procedure in effect. Repairs are made on an as needed basis.

4.3 Maintenance of Operating Facilities

There is no regular maintenance procedure for the operating facilities. Repairs are made as needed.

4.4 Description of Warning Systems

There are no warning systems in effect for this facility.

4.5 Evaluation

The current operation and maintenance procedures for this dam are inadequate to insure that problems encountered can be remedied within a reasonable period of time.

The owner should establish a written operational procedure as well as establishing a warning system to follow in the event of emergency conditions.

SECTION 5
HYDROLOGY AND HYDRAULIC ANALYSIS

5.1 Evaluation of Features

a. General. Cox District Reservoir Dam is an earthen structure with an overall length of 145 feet and a maximum hydraulic height of 20 feet. Near the left abutment there is a spillway with a crest length of 7.75 feet and walls 4.9 feet high. The control section is preceded by stoplogs and wingwalls. There is a concrete spillway chute on the downstream face of the dam which is on a 3 horizontal to 1 vertical slope. The gated 8 inch diameter outlet pipe is usually closed.

The impoundment is used as an emergency water supply for the Town of Woodstock. The dam is classified as small in size having a maximum storage of 21.1 acre-feet and a maximum height of 20 feet.

b. Design Data. No hydrologic or hydraulic design data were disclosed for this dam.

c. Experience Data. There are no records of maximum discharge at the site. However, it was reported that in June 1973 the water was flowing at a depth of three feet at the spillway section with the stoplogs removed. This would correspond to a discharge of about 125 cfs.

d. Visual Observations. No evidence of damage to any portion of the dam due to overtopping was visible at the time of inspection.

e. Test Flood Analysis. No detailed design and operational information are available for this dam. The hydrologic evaluation was performed using information gathered by field investigation, watershed characteristics, and Probable Maximum Flood (PMF) curves prepared by the Corps of Engineers. In accordance with Corps of Engineer Guidelines the significant hazard classification and small size classification of this dam warrants a test flood magnitude ranging from a 100 year flood to 1/2 the PMF. A test flood equal to the 100 year flood was used as the size of the reservoir was on the extreme low end of the classification range, that is a maximum storage of 21.1 acre-feet in the reservoir as opposed to a classification range extending to 1000 acre-feet. A test flood inflow of 550 cfs is based on a watershed of 1.08 square miles in mountainous terrain. The inflow of 550 cfs is equal to 1/5 the PMF. The proportion was obtained from the Weather Bureau's TP-40 Charts 50 and 51 which give the 6 hr Probable Maximum Precipitation PMP and the ratio of the 6 hr PMP to the 6 hr 100 year rainfall. It

was assumed that this proportion would be similar for runoff. As .65 square miles of the watershed is tributary to Vondell Reservoir, which is located upstream of Cox Reservoir, the 100 year flood tributary to it was routed. The outflow from Vondell Reservoir was added to that directly tributary to Cox Reservoir to obtain the total test flood inflow.

The routed test flood outflow was determined in accordance with Corps of Engineers Guidance for Estimating Effect of Surge Storage on Maximum Probable Discharge, and the hydraulic characteristics of the dam. The routing was started with the water surface at the crest of the spillway. It was assumed that stoplogs would be removed during this event. Flow through the spillway section was calculated by assuming it would pass through critical depth at the control section. Flow over the dam crest was calculated as flow over a broad crest weir. The routed test flood outflow was determined to be approximately 530 cfs. As the maximum capacity of the spillway is about 260 cfs (approximately 49 percent of the routed test flood outflow) the dam will be overtopped by 0.60 feet.

f. Dam Failure Analysis. The impact of failure of the dam was assessed using the "Rule of Thumb" Guidance for Estimating Downstream Dam Failure Hydrographs prepared by the Corps of Engineers. The breach discharge was estimated with the water surface at the crest of the dam and a breach width equal to 40 percent of the length of the dam at mid-height. The downstream hydrograph is a sum of the breach discharge and the maximum spillway discharge. Prior to the breach of dam the downstream river stage would be about 3 feet with the spillway at a full capacity discharge of 260 cfs. Breach of dam would result in an additional 6610 cfs for a total of 6870 cfs. The downstream stage was estimated using an average channel cross section in the reach between the dam and point 3800 feet downstream where the stream crosses a road. The breach flood stage in this reach varies from 11.5 feet at the dam to 7.6 feet at the end of the reach. About 1500 feet downstream of the dam there is a woodshed and another outbuilding located about 5 feet above the channel. At the end of the reach there are two dwellings one upstream of the road and about 5 feet above the channel and 100 feet away from the stream. Across the road downstream of the bridge is another dwelling set about 4 feet above the channel and 150 feet from the streambed. The roadway bridge consists of two 4 foot diameter pipes with the road surface 6 feet above the streambed. The valley section flattens out in this area and it is quite probable that the breach flood wave would be reduced from the calculated 7.6 feet. Route 4 is located another 1500 feet downstream.

The Woodstock Union High School is not in the hazard area of the breach flood wave considered in this report.

SECTION 6 STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observation. The visual inspection of Cox District Reservoir Dam revealed seepage from beneath the concrete spillway structure which is located on the downstream slope. This condition must be corrected before it leads to further instability.

Large, live and dead trees are located on the downstream slope. In one case, a 2 1/2 foot diameter tree and its large root system are within 6 feet of the concrete spillway structure on the downstream slope. These trees must be removed before their roots lead to serious piping and erosion problems.

b. Design and Construction Data. No design or construction data were made available.

c. Operating Records. No operating records were made available.

d. Post-Construction Changes. No design and construction data were available for review. In view of the size and condition of the dam, based on visual observation, it is important to ascertain how the dam is constructed.

An inspection report dated April 16, 1952 describes the dam as having a concrete core wall. This comment could not be verified during this inspection and it is considered important to determine if the concrete wall which exits on the upstream slope is a core wall that penetrates the entire dam or is only a superficial structure.

e. Seismic Stability. The dam is located in Seismic Zone 2, and in accordance with the recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7
ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual inspection of Cox District Reservoir Dam indicates that the dam is in poor condition. The inspection revealed the following:

(1) Significant seepage is exiting onto the downstream face from beneath the spillway structure. Seepage from beneath the spillway is also exiting in the discharge channel 2 feet below the end of the structure.

If left unattended, this seepage could lead to instability of the spillway structure by undermining.

(2) Dense vegetation on the embankment makes it impossible to adequately examine the downstream slope. The seepage near the spillway is a particularly poor condition.

The dense vegetation prevents adequate inspection to determine if seepage or wet areas exist on other areas of the downstream slope.

(3) Large trees with large root systems are growing on the downstream slope of the embankment. In one case, a 2 foot diameter tree with a large visible root system is growing on the slope within 6 feet of the spillway structure.

(4) Several cracks were observed in the "U" section of the spillway on the downstream face of the dam.

(5) There is no means for dewatering the reservoir.

(6) The gate for the 8 inch pipe is located on the downstream side of the dam.

The hydraulic analysis reveals that the spillway cannot pass the routed test flood without overtopping the dam.

b. Adequacy of Information. The lack of in-depth engineering data did not allow for a definitive review. Therefore, the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data but is based primarily on visual inspection, past performance history and sound engineering judgment.

c. Urgency. This dam is in generally poor condition. The recommendations and remedial measures described in Sections 7.2 and 7.3 should be accomplished within 1 year after receipt of this Phase I Inspection Report by the owner.

d. Necessity of Additional Investigation. No additional investigation is needed to complete the Phase I inspection.

7.2 Recommendations

The owner should remove the spillway stoplogs until all repairs have been completed. In addition, the owner should engage a qualified registered professional engineer to (1) investigate the cause and effects of the seepage beneath the spillway structure and to design remedial measures to prevent uncontrolled seepage in this area, (2) design an acceptable means of removing the trees and their roots from the dam and backfilling the voids with appropriate material, (3) determine what the dam is constructed of and if the concrete wall exiting on the upstream slope is a core wall which extends into the foundation, (4) investigate spillway adequacy and consider any modifications if necessary, and (5) consider the necessity of providing a means for dewatering the reservoir, and relocating the 8 inch gate valve on the upstream side of the dam.

7.3 Remedial Measures

(a) Remove brush and small trees and cut vegetation on crest and slopes of the dam.

(b) Remove the debris in the discharge channel.

(c) Consider replacement or removal of the planks across the spillway.

(d) Repair all cracked and spalled concrete.

(e) Prepare a downstream warning system in the event of an emergency.

(f) A technical inspection program should be initiated and continued on a yearly basis.

7.4 Alternatives

There are no practical alternatives to the recommendations of Sections 7.2 and 7.3.

APPENDIX A
INSPECTION CHECKLIST

A-1

VISUAL INSPECTION CHECK LIST
PARTY ORGANIZATION

PROJECT Cox Reservoir DamDATE 9/12/79TIME 9:30 AMWEATHER FairW.S. ELEV. 968.7 U.S. - DN.SPARTY:

1. <u>D. LaGatta</u>	<u>GEI</u>	6. _____
2. <u>S. Mazur</u>	<u>HNTB</u>	7. _____
3. <u>R. Yarsites</u>	<u>HNTB</u>	8. _____
4. _____		9. _____
5. _____		10. _____

PROJECT FEATURE	INSPECTED BY	REMARKS
1. <u>Dam</u>	<u>Dan LaGatta</u>	
2. <u>Spillway, Outlet and</u>	<u>Stan Mazur</u>	
3. <u>Downstream Channel</u>	<u>Robert Yarsites</u>	
4. _____		
5. _____		
6. _____		
7. _____		
8. _____		
9. _____		
10. _____		

PERIODIC INSPECTION CHECK LIST

A-2

PROJECT Coxe DistrictDATE September 12, 1979PROJECT FEATURE Embankment Dam

NAME _____

DISCIPLINE Geotechnical EngineerNAME D.P. LaGatta

AREA EVALUATED	CONDITION
<u>DAM EMBANKMENT</u>	
Crest Elevation	971.9
Current Pool Elevation	968.7
Maximum Impoundment to Date	unknown
Surface Cracks	None visible - vegetation very dense
Pavement Condition	No pavement
Movement or Settlement of Crest	None observed
Lateral Movement	
Vertical Alignment	No misalignment observed
Horizontal Alignment	
Condition at Abutment and at Concrete Structures	Seepage exiting from beneath spillway training wall on to embankment
Indications of Movement of Structural Items on Slopes	Numerous cracks in concrete training walls of spillway on D.S. slope
Trespassing on Slopes	None
Sloughing or Erosion of Slopes or Abutments	Dense vegetation prevents evaluation
Rock Slope Protection - Riprap Failures	No riprap
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Seepage from beneath spillway structure on d.s. slope
Piping or Boils	None observed
Foundation Drainage Features	None
Toe Drains	None
Instrumentation System	None
Vegetation	Very dense vegetation on crest of d.s. slope. Trees and brush.

PERIODIC INSPECTION CHECK LIST

A-3

PROJECT Cox Reservoir Dam

DATE 9/12/79

PROJECT FEATURE Intake Channel/Structure

NAME D. LaGatta

DISCIPLINE Geotechnical/Structural

NAME S. Mazur

AREA EVALUATED

CONDITION

OUTLET WORKS - INTAKE CHANNEL AND INTAKE STRUCTURE

a. Approach Channel

Slope Conditions

Bottom Conditions

Rock Slides or Falls

Log Boom

Debris

Condition of Concrete Lining

Drains or Weep Holes

b. Intake Structure

Condition of Concrete

Stop Logs and Slots

No intake channel or visible intake structure.

Fair, some surface deterioration was noted.

Good.

PERIODIC INSPECTION CHECK LIST

A-5

PROJECT Cox Reservoir Dam

DATE 9/12/79

PROJECT FEATURE Outlet Works Conduit

NAME S. Mazur

DISCIPLINE Structural/Hydraulic

NAME R. Yarsites

AREA EVALUATED

CONDITION

OUTLET WORKS - TRANSITION AND CONDUIT

General Condition of Concrete

Rust or Staining on Concrete

Spalling

Erosion or Cavitation

Cracking

Alignment of Monoliths

Alignment of Joints

Numbering of Monoliths

The pond is drained by an 8" Dia. pipe as shown in Section C-C, Figure 2/2. The pipe is controlled by valve located in concrete chamber. It was reported that pond drain is in good condition.

PERIODIC INSPECTION CHECK LIST

A-4

PROJECT Cox Reservoir Dam

DATE 9/12/79

PROJECT FEATURE _____

NAME _____

DISCIPLINE _____

NAME _____

AREA EVALUATED

CONDITION

OUTLET WORKS - CONTROL TOWER

a. Concrete and Structural

General Condition

Condition of Joints

Spalling

Visible Reinforcing

Rusting or Staining of Concrete

Any Seepage or Efflorescence

Joint Alignment

Unusual Seepage or Leaks in Gate Chamber

Cracks

Rusting or Corrosion of Steel

b. Mechanical and Electrical

Air Vents

Float Wells

Crane Hoist

Elevator

Hydraulic System

Service Gates

Emergency Gates

Lightning Protection System

Emergency Power System

Wiring and Lighting System

This facility has no tower.

PERIODIC INSPECTION CHECK LIST

A-6

PROJECT Coxe DistrictDATE September 12, 1979PROJECT FEATURE Embankment Dam

NAME _____

DISCIPLINE Geotechnical EngineerNAME D.P. LaGatta

AREA EVALUATED

CONDITION

OUTLET WORKS - OUTLET STRUCTURE AND
OUTLET CHANNEL

General Condition of Concrete

Rust or Staining

Spalling

Erosion or Cavitation

Visible Reinforcing

Any Seepage or Efflorescence

Condition at Joints

Drain Holes

Channel

Loose Rock or Trees Overhanging
Channel

Condition of Discharge Channel

No outlet structure on dam or outlet
channel. Water piped from reservoir
into water supply system.

PERIODIC INSPECTION CHECK LIST

A-7

PROJECT Cox Reservoir Dam DATE 9/12/79
 PROJECT FEATURE Outlet Works - Spillway NAME D. LaGatta
 DISCIPLINE Geotechnical/Hydraulic/Structural NAME R. Yarsites, S. Mazur

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u> a. Approach Channel General Condition Loose Rock Overhanging Channel Trees Overhanging Channel Floor of Approach Channel b. Weir and Training Walls General Condition of Concrete Rust or Staining Spalling Any Visible Reinforcing Any Seepage or Efflorescence Drain Holes c. Discharge Channel General Channel Condition Loose Rock Overhanging Channel Trees Overhanging Channel Floor of Channel Other Obstructions	<p>Spillway passes through dam on left abutment. No approach channel to spillway entrance which is on dam slope.</p> <p>Fair, considerable concrete deterioration was noted. Staining-walls and slab. Spalling at training walls None Seepage at spillway channel slab.</p> <p>Concrete spillway channel on d.s. slope in poor condition. Water seeping from beneath concrete structure onto embankment. Discharge channel is in poor condition. Note: dye test performed to determine source of water emerging from beneath spillway structure. Test indicated water flowing under spillway slab from top of spillway.</p>



PHOTO NO. 9 - Spillway and wingwalls. Planks span structure.



PHOTO NO. 10 - View of spillway structure and left wingwall.
Note planks on the top of the photo and the stoplogs in
the foreground.



PHOTO NO. 7 - Dead elm tree
on downstream slope.

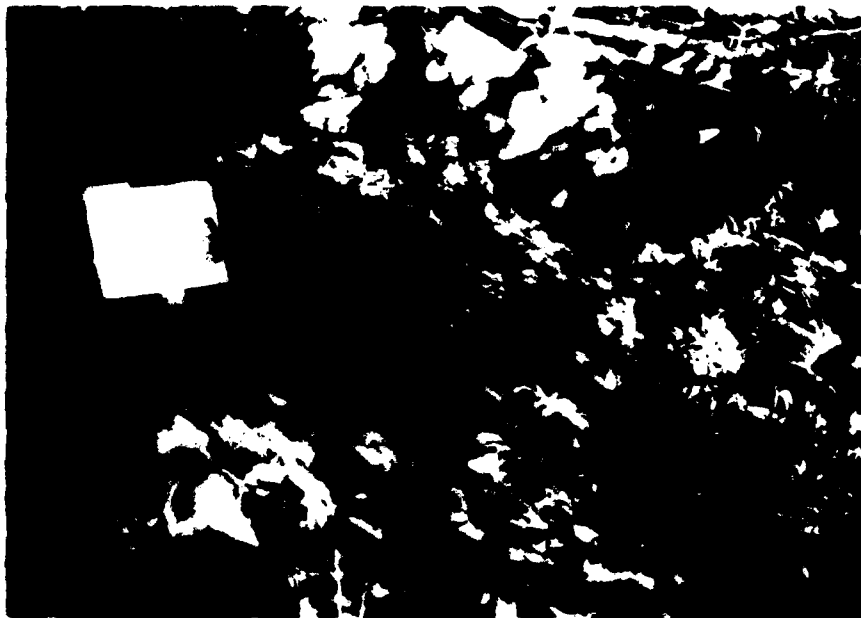


PHOTO NO. 8 - Tree root system located 6 feet from spillway
training wall.



PHOTO NO. 5 - Toe of downstream embankment looking toward right abutment.

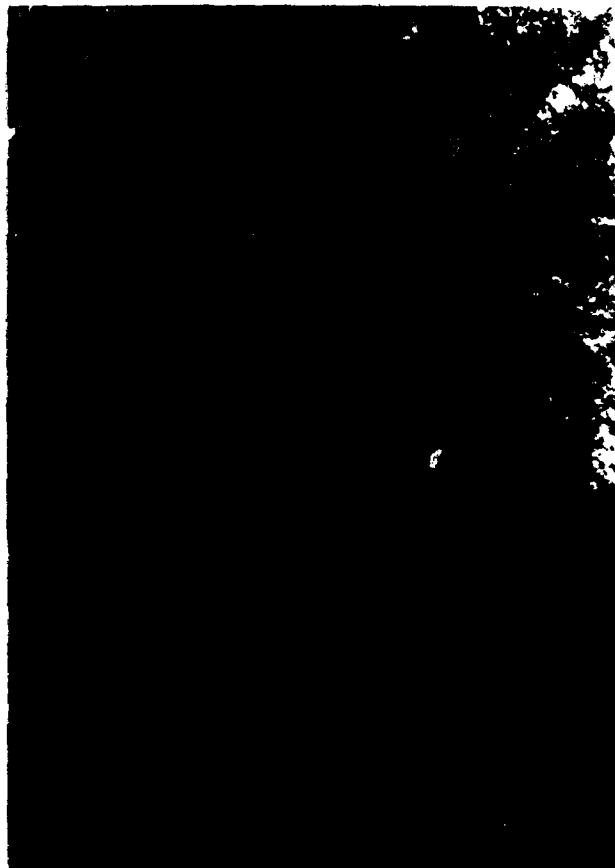


PHOTO NO. 6 - Trees on downstream slope near right abutment contact.



PHOTO NO. 3 - Crest of dam from
left abutment. Planks span
spillway.

PHOTO NO. 4 - Downstream
face of embankment as
viewed toward right
abutment from a point
midway between the crest
and toe of slope.





PHOTO NO. 1 - Upstream face of dam from left bank of reservoir.

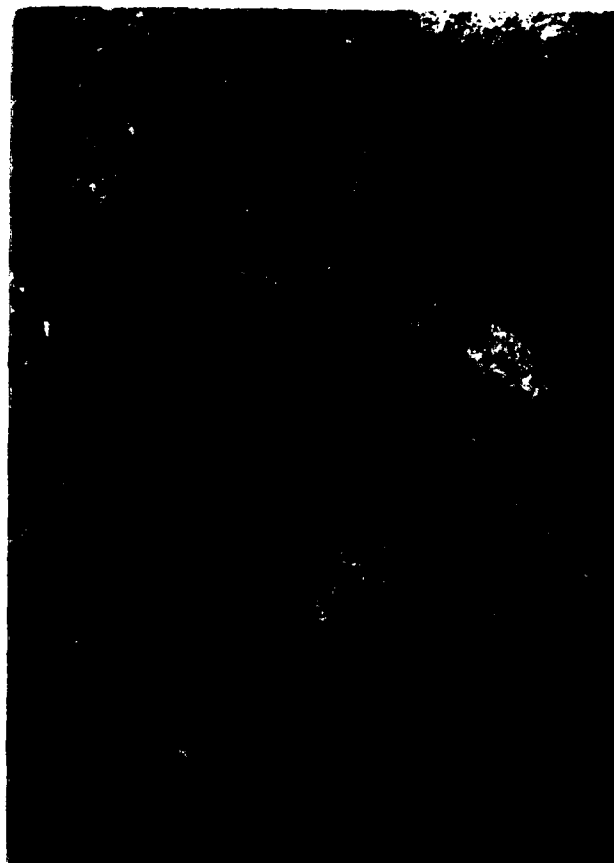
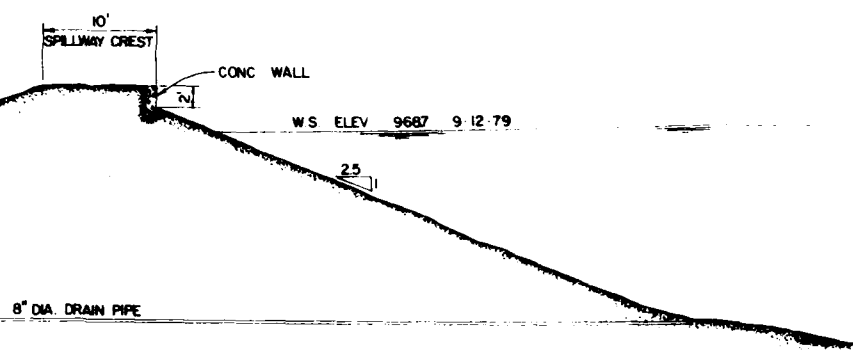


PHOTO NO. 2 - Upstream face
of dam, showing concrete
wall emerging from
embankment.

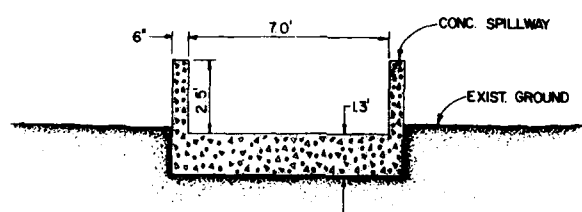
APPENDIX C

PHOTOGRAPHS

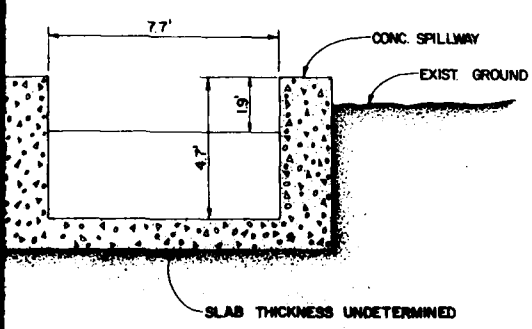
FOR LOCATION OF PHOTOS, SEE FIGURE 1
LOCATED IN APPENDIX B



SECTION C-C



SECTION F-F

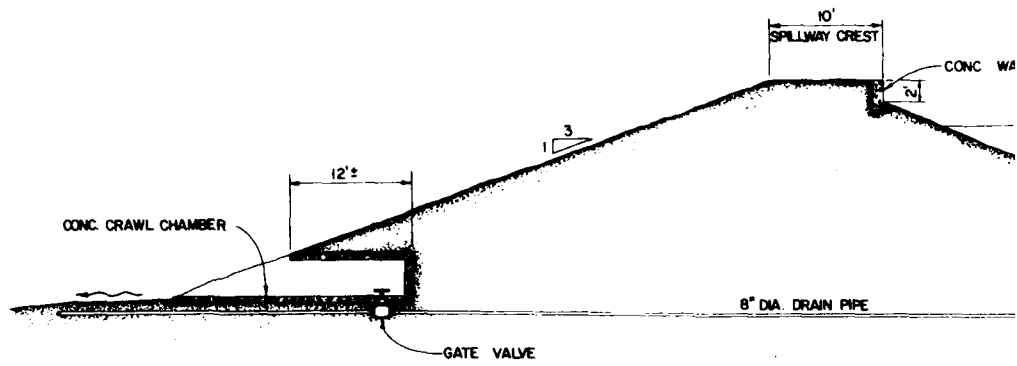


SECTION E-E

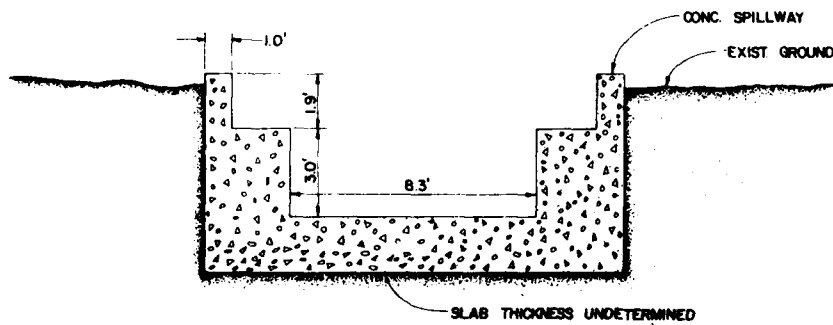
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2. THE ELEVATIONS SHOWN IS N.G.V.D. 1929.

DESIGNED BY: [blank]	U.S. ARMY ENGINEER DIV. NEW ENGLAND
CHECKED BY: [blank]	BRANCH OF [blank]
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS	
COX DISTRICT RESERVOIR DAM	
TRIBUTARY TO OTTAUQUECHEE RIVER	WOODSTOCK, VERMONT
[blank]	[blank]
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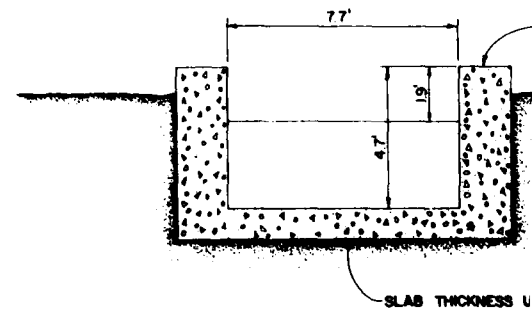
Figure 2 of 2



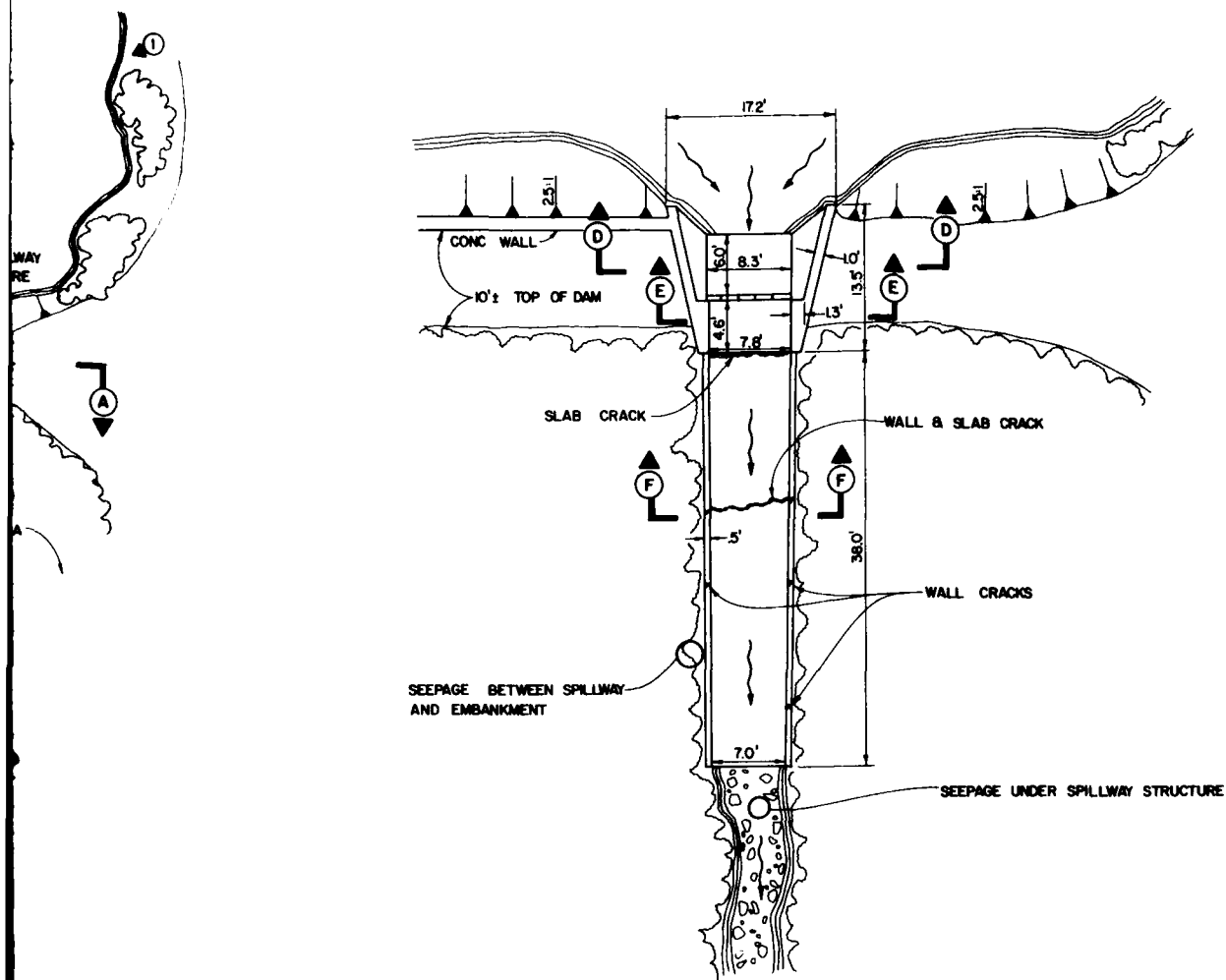
SECTION C-C



SECTION D-D

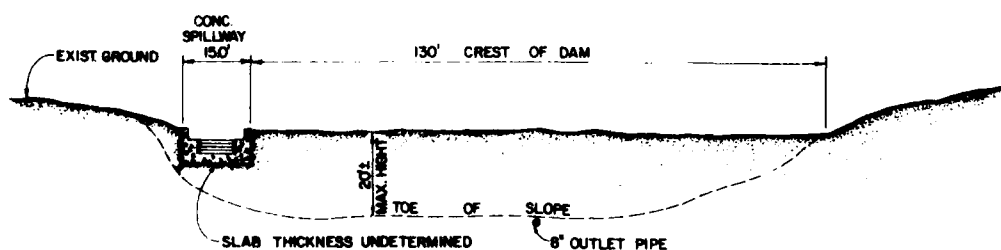


SECTION E-E



PLAN OF SPILLWAY

E OF POND BOTTOM



SECTION A-A

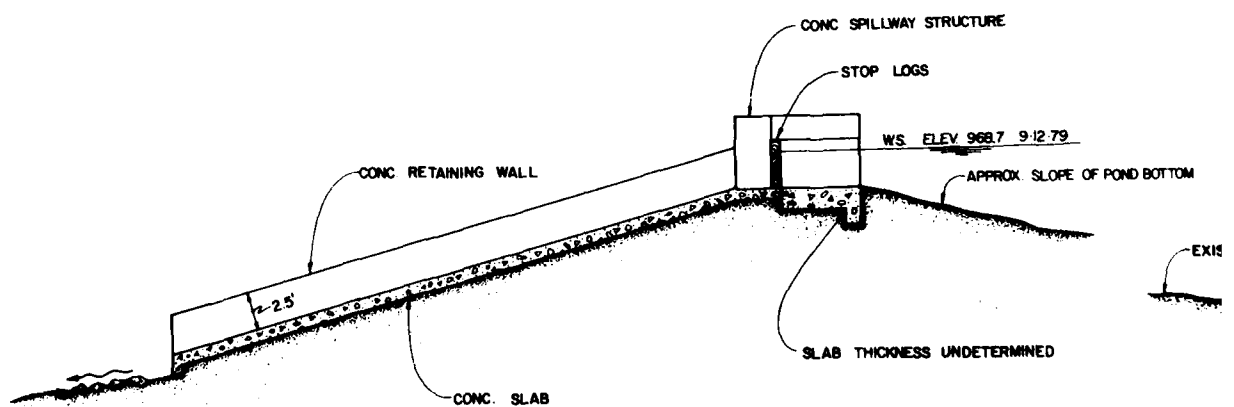
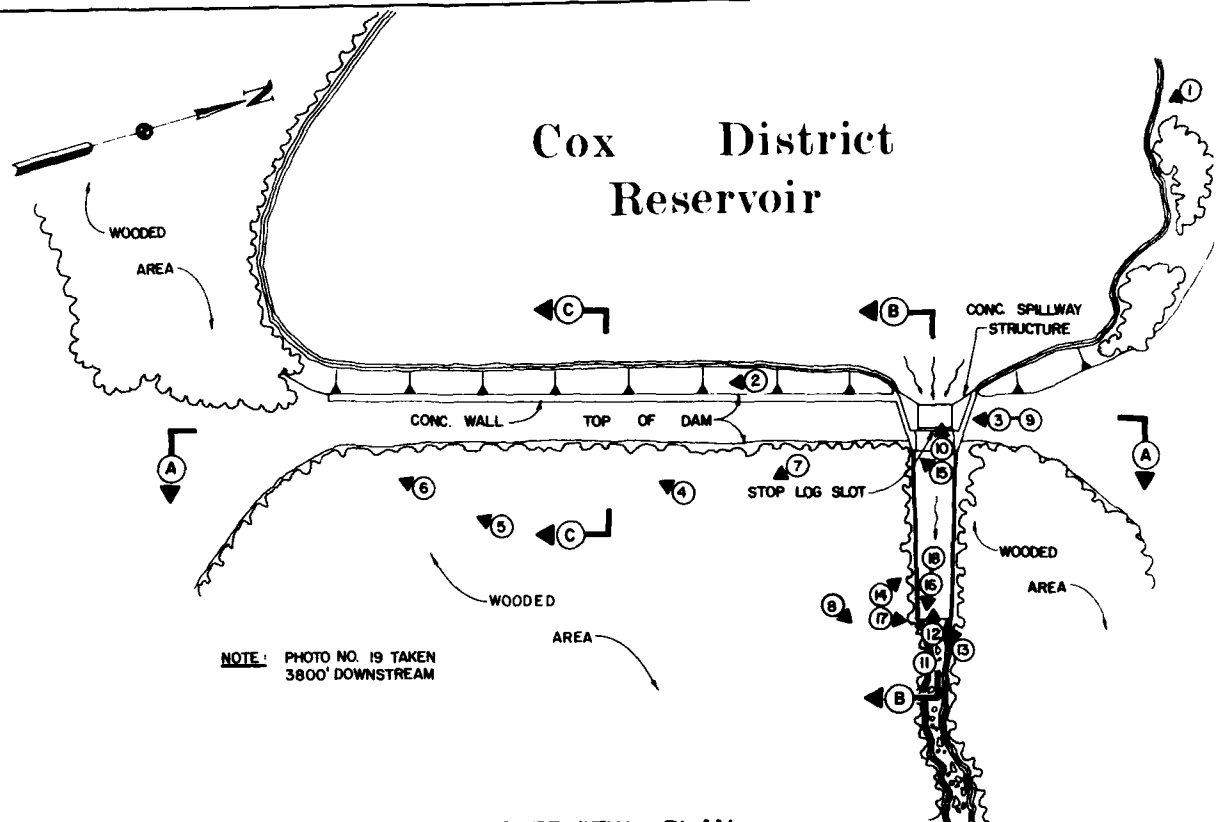
② INDICATES PHOTO LOCATION & DIRECTION

1. THE INFORMATION SHOWN ON THESE DRAWINGS IS BASED ON THE ORIGINAL CONSTRUCTION PLANS AND VISUAL OBSERVATIONS MADE DURING THE FIELD INSPECTION. DIMENSIONS OR MATERIALS INDICATED ON THESE DRAWINGS WHICH WERE BELOW GRADE OR WATER DURING THE TIME OF INSPECTION WERE NOT VERIFIED.

2. THE ELEVATIONS SHOWN IS N.G.V.D. 1929.

ENGINEER, DESIGN, DRAWING & CONSTRUCTION SECTION, DAMS AND LEVEES 1175	U.S. ARMY ENGINEER DIV NEW ENGLAND ROOM 301 BOSTON, MASS
NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS	
COX DISTRICT RESERVOIR DAM	
TRIBUTARY TO OTTAWAQUECHEE RIVER	WOODSTOCK, VERMONT

Cox District Reservoir



5/20/54
OK

INSPECTION REPORT
ON
Coxe District Reservoir Dam

1. Date of inspection 4/16/52 2. Water conditions normal

GENERAL DATA:

3. Location of dam a small brook at West Woodstock
4. Owner and operator Woodstock Aqueduct Co.
5. Characteristic features of dam earth dam 160' long, 30' high
with core wall;
concrete lined chute spillway at east end.
6. Other related data Used for water supply
surface area = 1.5 acres; volume 670,000 cu. ft. D.A. = 13.5 mi.

OBSERVATIONS:

7. Condition of structure embankment - no upstream slope
protection but good grass cover top & downstream
seepage along outside of chute spillway,
wetness at toe.
Concrete - good
8. Condition of equipment good
9. Operation _____
10. Maintenance good - new lining for chute
spillway

REMARKS:

dam on hard pan foundation.

Inspected by JH

PAST INSPECTION REPORTS

APPENDIX B
ENGINEERING DATA

1. LIST OF DESIGN, CONSTRUCTION AND MAINTENANCE
RECORDS - NONE AVAILABLE
2. PAST INSPECTION REPORTS
3. PLAN AND DETAILS

PERIODIC INSPECTION CHECK LIST

A-8

PROJECT Cox Reservoir Dam

DATE 9/12/79

PROJECT FEATURE Service Deck/Spillway

NAME S. Mazur

DISCIPLINE Structural

NAME _____

AREA EVALUATED

CONDITION

OUTLET WORKS - SERVICE BRIDGE

a. Super Structure

Bearings

Anchor Bolts

Bridge Seat

Longitudinal Members

Under Side of Deck

Secondary Bracing

Deck

Drainage System

Railings

Expansion Joints

Paint

b. Abutment & Piers

General Condition of Concrete

Alignment of Abutment

Approach to Bridge

Condition of Seat & Backwall

Service Deck over spillway consists of loose 2x10 and 2x8 wood boards, condition poor.



PHOTO NO. 11 - View of spillway. Note stoplogs at top and in the background.



PHOTO NO. 12 - Spillway looking upstream from end of floor slab.



PHOTO NO. 13 - Spillway left wall from end of floor slab.



PHOTO NO. 14 - Seepage exiting from beneath right wall of spillway onto downstream face of embankment. Seep is located 10 feet from toe of embankment.

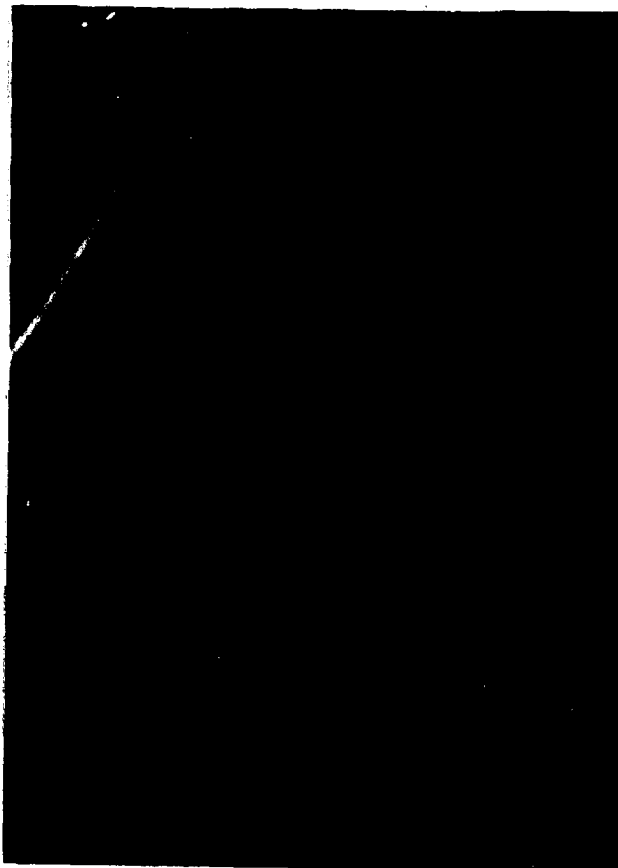


PHOTO NO. 15 - Joint between
spillway and spillway where
green dye was injected.

PHOTO NO. 16 - Channel
immediately downstream
of spillway. Note green
dye exiting from channel
floor 2 feet downstream
of spillway structure.





PHOTO NO. 17 - End of spillway.



PHOTO NO. 18 - Discharge channel.



PHOTO NO. 19 - Road crossing outlet stream located 3800 feet downstream of dam.

C-10

APPENDIX D
HYDROLOGIC AND HYDRAULIC COMPUTATIONS

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF For <u>Cox Dis. Res.</u>	Made by <u>RY</u>	Date <u>9/21/77</u>	Job No. <u>5965-11-17</u>
	Checked by <u>HM</u>	Date <u>10/16/79</u>	Sheet No. <u>1</u>

Hydraulics & Hydrology

Cox District Reservoir is located on a tributary to the Ottauquechee River in the town of Woodstock, Windsor Co., Vermont, in the Connecticut River Basin.

Classification: Size: Small
Hazard: Significant

Basic Data: D.A. 1.08 sq mi
Watershed Slope 367 ft/mi
0.65 sq mi Tributary to Vandell Res located 4700' upstream.

Reservoir: Normal Surface Area 1.53 Ac
Storage 18.4 AF
Elev 970.0
Top of Dam Storage 21.1 Af
Elev 971.9
Assume Vertical prism storage

Dam: Earth
Length 130'
height 20'

Spillway: Concrete
Opening width 7.75 ft
Crest 967.0
Stop Log control.

HNTB HOWARD NEEDLES TAMMEN & BERGENCOFF For <u>Cox</u>	Made by <u>RY</u>	Date <u>9/21/79</u>	Job No. <u>5965-11-17</u>
	Checked by <u>HM</u>	Date <u>5/16/79</u>	Sheet No. <u>2</u>

Step 1 Calculation of Test Flood Inflow

Classification Size: Small
Hazard: Significant

Hydrologic Evaluation Headline Recommends

100yr Freq Flood to $1/2$ PMF

Use 100 year Flood as reservoir is on low end of classification range 21.5 acre ft vs a maximum of 999 acre ft.

As the Basin is in a mountainous area (ave basin slope 370 ft/mi) and the area is outside the PMF curve envelope take the maximum PMF of 3000 csm; and,

According to the Weather Bureau TP-40 Chart 51 the ratio between the 6 hr PMP and the 100 year rainfall is 5.0 in Windsor Co. Vt. For this analysis it is assumed that the same relationship will hold true for runoff.

Therefore

$$\frac{1}{5} \times 3000 \text{ csm} = 600 \text{ csm for this basin for 100 year flood.}$$

This same relationship would be true for the PMF runoff.

$$\text{thus } \frac{1}{5} \times 19" = 3.8 \text{ inches}$$

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF For <u>Cox</u>	Made by <u>RY</u>	Date <u>9/21/77</u>	Job No. <u>5965-11-20</u>
	Checked by <u>HM</u>	Date <u>10/16/79</u>	Sheet No. <u>3</u>

0.65 mi² of the basin is tributary to Vondell Res.
located 4700' upstream of Cox Dis. Res.

Inflow to this reservoir is $600 \times .65 = 390$ cfs

Outlet works consist of concrete spillway
discharging to a 6' ϕ pipe. Control is at the
7.0' wide spillway section.

$Q = CLH^{3/2}$ $C = 3.4$ The emergency spillway is set
about 3 ft above the crest of the outlet weir
and has a 24' BW assume de control.

Stage	Discharge	Emergency	Total
0 ft	0 cfs	0	0
1	24	0	24 cfs
2	67	0	67
3	124	0	124
4	190	74 cfs	264
5	270	210	490

Stage-Discharge Curve is shown on fig 1

Reservoir Routing Curve Surface Area 8.4 Ac
Storage vertical prism

$$Q_{P2} = Q_1 \times \left(1 - \frac{\text{Stor}}{3.8}\right) \quad Q_{P1} = 390 \text{ cfs}$$

$$\text{Stor} = \frac{\text{Stage} \times 8.4 \times 12 \text{ in/ft}}{0.65 \text{ mi}^2 \times 640 \text{ acre/mi}^2} = 0.24 \text{ Stage}$$

Stage	Stor	Q_{P2}
1	.24 in	365 cfs
2	.48	340
3	.73	315
4	.97	290
5	1.21	265

See fig 1 for plot

Outflow = 290 cfs

HNTB HOWARD NEEDLES TAMMEN & BERENDSON For <u>Cox</u>	Made by <u>RY</u>	Date <u>9/24/79</u>	Job No. <u>5965-11-17</u>
	Checked by <u>H</u>	Date <u>10/16/79</u>	Sheet No. <u>4</u>

Flow Directly tributary to Cox Res.

$$D.A. = .43 \text{ mi}^2$$

Basin Similar to area tributary to Vendell

$$Q_p = \frac{1}{5} \times 3000 \text{ csm} \times .43 \text{ mi}^2 = 258 \text{ cfs say } 260 \text{ cfs}$$

Assume no lag From Vendell res. outflow

therefore:

$$Q_p = 260 \text{ cfs} + 290 \text{ cfs} = 550 \text{ cfs}$$

Step 2. Calculation of Surcharge

Spillway-Discharge - See fig 1 of 1 Appendix "B" for Plan & Details of Structure.

Assume flow through spillway passes through critical depth. & Stop logs removed.

$$Q = d_c^{3/2} \sqrt{g} b \quad b = \text{width} = 7.75'$$

$$Q = 3.09(7.75) H^{3/2} \quad d_c = H/1.5$$

$$Q = 23.95 H^{3/2}$$

Discharge over dam crest.

$$\text{Broad crest weir } Q = CLH_b^{3/2}$$

$$C = 3.08$$

$$L = 130 \text{ feet} \cdot \text{dam crest length}$$

$$H_b = H - 4.9'$$

$$Q = 400.4 (H - 4.9)^{3/2}$$

D4

HNTB HOWARD NEEDLES TAMMEN & BERGENCOFF For <u>Cox</u>	Made by <u>RY</u>	Date <u>9/24/79</u>	Job No. <u>5965-11-17</u>
	Checked by <u>HM</u>	Date <u>10/16/79</u>	Sheet No. <u>5</u>

Stage - Discharge Curve

<u>Elev</u>	<u>H</u>	<u>Spillway Discharge</u>	<u>H-4.9</u>	<u>Crest Discharge</u>	<u>Q_{Total}</u>
967.0	0	0	0	0	0
969.0	2.0 ft	68 cfs	0	0	68 cfs
970.9	3.9	184	0	0	184
971.9	4.9	260	0	0	260
972.2	5.2	284	.3 ft	66 cfs	350
972.5	5.5	309	.6 ft	186	495
972.7	5.7	326	.8	286	612

See Figure 2 For plot

Step 3 Calculation of Surge Effect

$$Q_p = 550 \text{ cfs}$$

Storage Vertical prism above
elev 970. $SA = 1.53 \text{ Ac}$

$$Q_{p2} = Q_p \times (1 - \text{Stor}/3.8")$$

$$R_o = 3.8 \text{ min}$$

$$\text{Stor} = \frac{\text{Stage} \times 1.53 \text{ Ac} \times 12 \text{ in/ft}}{1.08 \text{ mi}^2 \times 640 \text{ ac/mi}^2} = .0266 \times \text{Stage}$$

<u>Stage</u>	<u>Stor</u>	<u>Q_{p2}</u>
970	.08	538 cfs
971	.11	534
972	.13	530
973	.16	526

See Fig 2 for Plot

From Fig 2

Out flow 530 cfs

Stage 5.5 ft

Stage over dam crest 0.6 ft

Spillway Discharge At top of Dam 260 cfs, % of Test Flood Outflow 49%

D-5

Figure 1

10:10 TO THE INCH

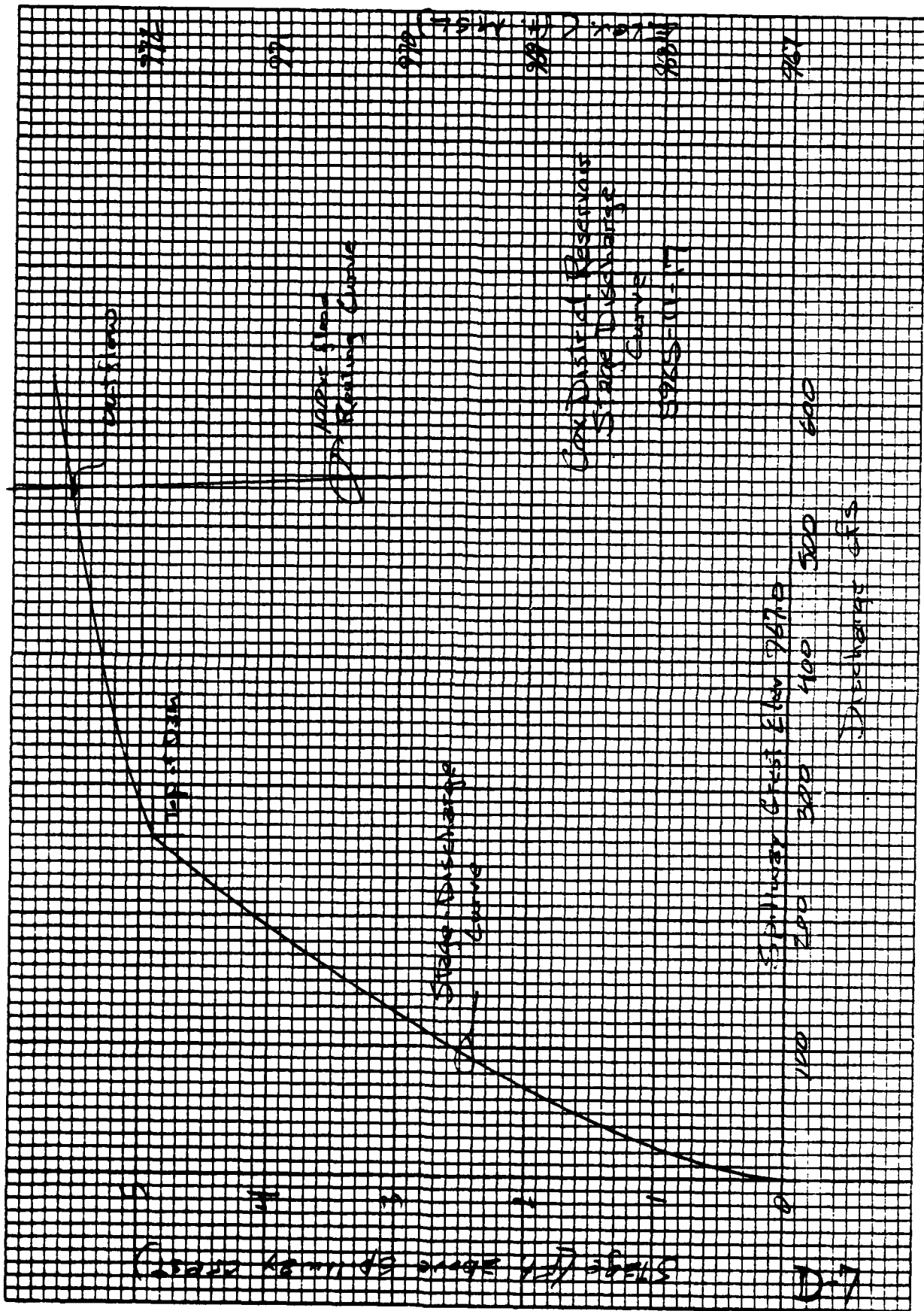


Figure 2

HNTB

HOWARD NEEDLES TAMMEN & BERGENDOFF

Made by

RY

Date

9/14/79

Job No.

5965-11-17

Checked by

HM

Date

10/16/79

Sheet No.

6

For Cox Dis. Res.

Estimate of Downstream DamageStep 1 Reservoir Storage

Normal Water Surface 970.0

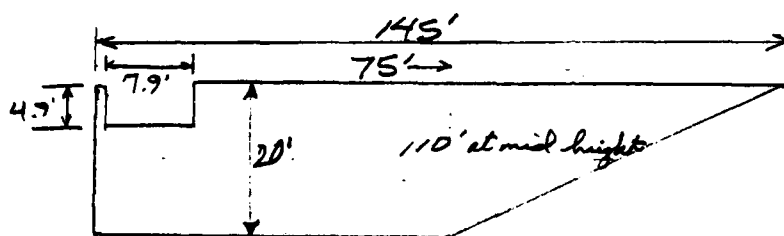
Storage 6.0 mg = 18.4 acre-feet

Top of Dam 971.9

Storage 21.1 acre-ft

Step 2 Breach Outflow

$$Q_{\text{Breach}} = 8/27 \sqrt{g} w_0 y_0^{3/2}$$

 $w_0 = 40\%$ of dam length at mid height $.40 \times 110$ $y_0 = \text{max height top of dam to streambed} = 20'$

$$Q_{\text{Breach}} = 8/27 \sqrt{g} (.4)(110)(20)^{3/2} = 6611 \text{ cfs}$$

Spillway Capacity 7'-9" wide \times 4'-9" h dc through outlet

$$dc + \frac{V^2}{2g} = 4.75 \text{ ft} = h$$

$$Q = \sqrt{g} b dc^{3/2} \quad Q = A \times V \quad dc + \frac{dc}{2} = h \quad \frac{h}{1.5} = dc$$

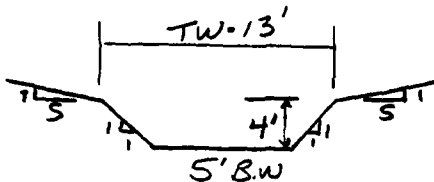
$$Q = \sqrt{g} (7.75) \left(\frac{4.90}{1.5}\right)^{1.5} \quad Q = 260 \text{ cfs}$$

Total Discharge 6870 cfs

D-8

HNTB HOWARD NEEDLES TAMMEN & BERENDSON For <u>COX</u>	Made by <u>RV</u>	Date <u>9/14/79</u>	Job No. <u>5965-11-17</u>
	Checked by <u>HM</u>	Date <u>10/6/79</u>	Sheet No. <u>7</u>

Step 3 Stage-Discharge Downstream Channel



Reach Characteristics

$$\text{Slope} = .0579'$$

$$L = 3800'$$

$$n_{\text{channel}} = .05'$$

$$n_{\text{overbank}} = .08$$

Stage	Discharge
2 ft	120 cfs
4	440
6	1170
8	2500
10	4650
12	7780

Step 4 Reach Outflow

$Q_{P1} = 6870 \text{ cfs}$ $L = 3800 \text{ ft}$ $S = 21.1 \text{ ac/ft}$
 Reach 1A $\text{Stage} = 11.5 \text{ ft}$ $L_A = 1000 \text{ ft}$
 1000 cfs $A = 415 \text{ sq ft}$
 3800 ft $V_1 = \frac{1000 \times 415}{43560} = 9.53 \text{ AF} < \frac{21.1 \text{ AF}}{2}$ Reach section OK

$$Q_{P_{1T}} = Q_{P1} \left(1 - \frac{V_1}{S}\right) = 6870 \left(1 - \frac{9.53}{21.1}\right) = 3760 \text{ cfs}$$

$$\text{Stage}_2 = 9.3 \text{ ft} \quad \text{area}_2 = 245 \text{ sq ft}$$

$$V_2 = \frac{1000 \times 245}{43560} = 5.62 \text{ ac/ft}$$

$$V_{ave} = 7.58 \text{ ac/ft}$$

$$Q_{P2} = 6870 \left(1 - \frac{7.58}{21.1}\right) = 4400 \text{ cfs} =$$

$$\text{Stage} = 9.8 \text{ ft}$$

D-9

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF	Made by	RV	Date	9/14/79	Job No.	3965-11-17
	Checked by	HM	Date	10/16/79	Sheet No.	8
For Cox						

Reach 1B L = 1300 ft

$$Q_{P1} = 4400 \text{ cfs}$$

$$\text{Stage}_1 = 9.8 \text{ ft} \quad \text{area}_1 = 280 \text{ m}^2$$

$$V_1 = \frac{1300 \text{ ft} \times 280}{43560} = 8.36 \text{ acre-ft}$$

$$Q_{P2T} = 4400 \left(1 - \frac{8.36}{21.1}\right) = 2660 \text{ cfs}$$

$$\text{Stage}_2 = 8.2' \quad \text{area}_2 = 179 \text{ m}^2$$

$$V_2 = \frac{1300 \times 179}{43560} = 5.34 \text{ acre-ft} \quad V_{ave} = 6.85 \text{ acre-ft}$$

$$Q_{P2} = 4400 \left(1 - \frac{6.85}{21.9}\right) = 2970 \text{ cfs}$$

Reach 1C L = 1500 ft $Q_{P1} = 2970 \text{ cfs}$

$$\text{Stage} = 8.5 \text{ ft} \quad \text{area}_1 = 196 \text{ m}^2$$

$$V_1 = \frac{1500 \times 196}{43560} = 6.75 \text{ acre-ft}$$

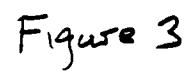
$$Q_{P2T} = 2970 \left(1 - \frac{6.75}{21.1}\right) = 2020 \text{ cfs}$$

$$\text{Stage}_2 = 7.4 \text{ ft} \quad \text{area}_2 = 138 \text{ m}^2$$

$$V_2 = \frac{1500 \times 138}{43560} = 4.75 \text{ acre-ft} \quad V_{ave} = 5.75 \text{ acre-ft}$$

$$Q_{P2} = 2970 \text{ cfs} \left(1 - \frac{5.75}{21.1}\right) = 2160 \text{ cfs}$$

$$\text{Stage}_2 = 7.6 \text{ ft}$$

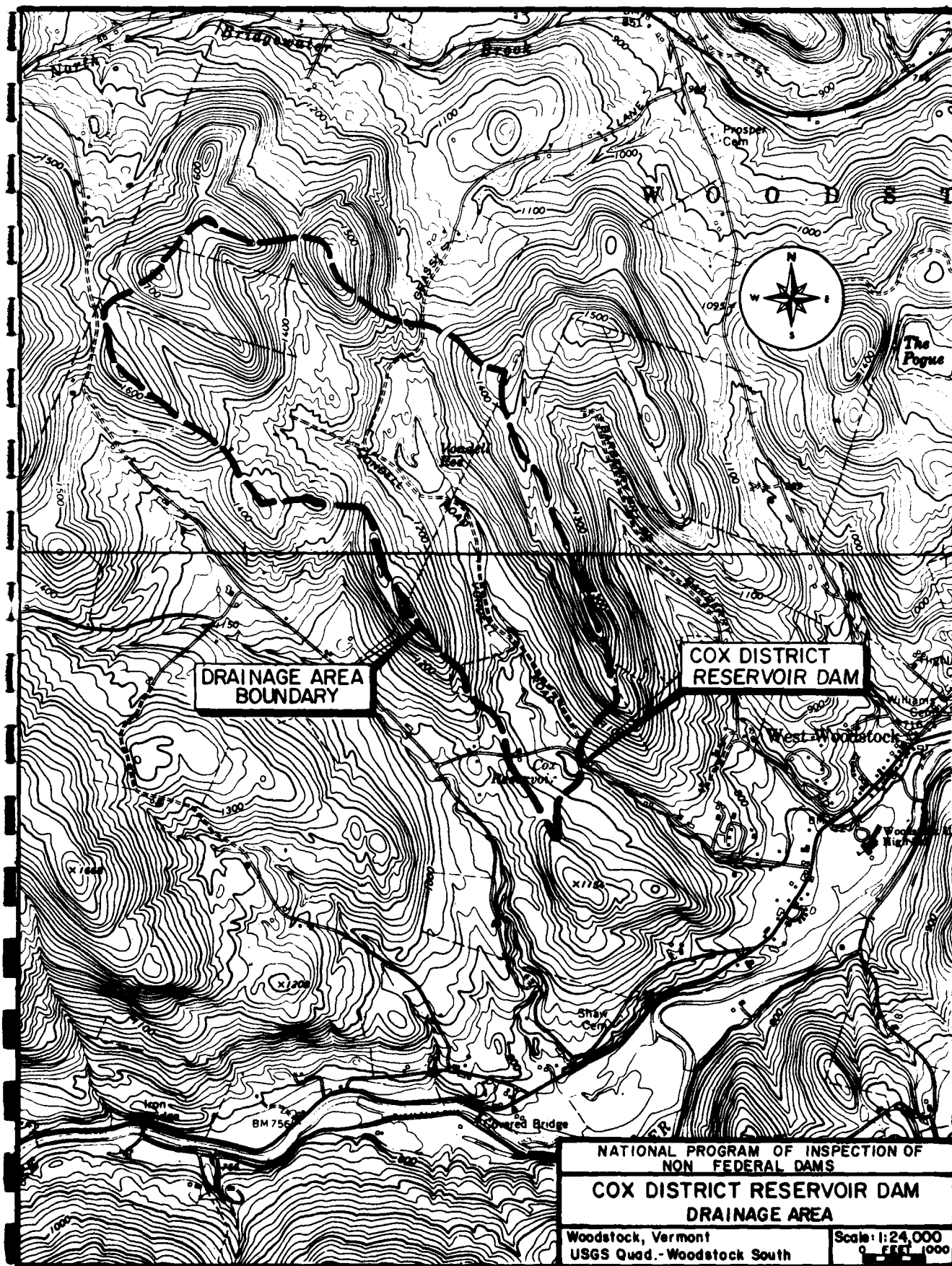


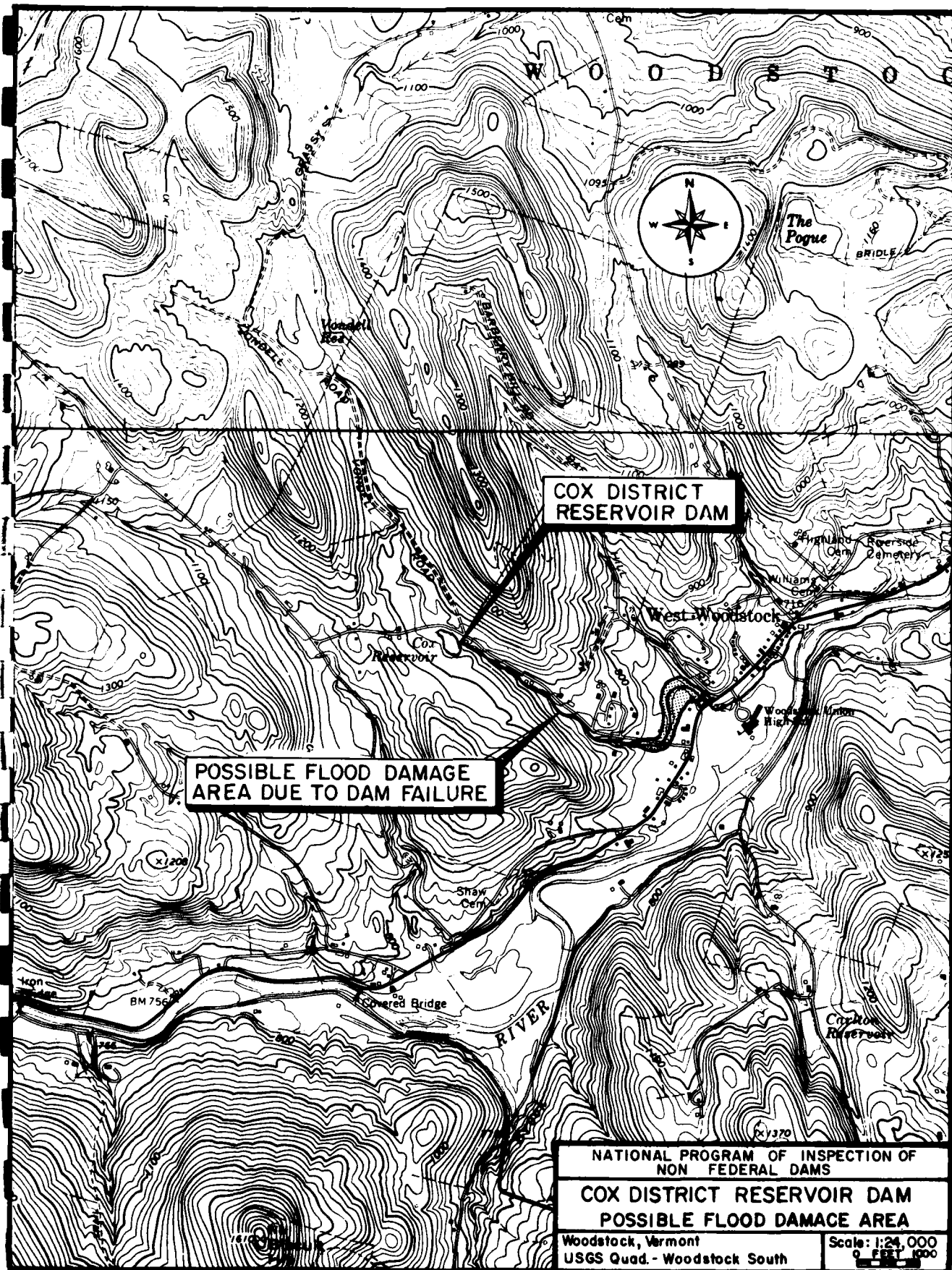
**PRECIPITATION FOR 10 SQUARE MILES
VS. 100 YEAR
6-HOUR RAINFALL**

TP-40



D-12





APPENDIX E

INFORMATION AS CONTAINED IN
THE NATIONAL INVENTORY OF DAMS



INVENTORY OF DAMS IN THE UNITED STATES

STATE	COUNTY	DIVISION	STATE	COUNTY	CONGR. DIST.	NAME	LATITUDE (NORTH)	LONGITUDE (WEST)	REPORT DATE
VT	WINDHAM		VT	WINDHAM	1	COX DISTRICT RESERVOIR DAM	43 57.0	72 55.8	1906179

POPULAR NAME	NAME OF IMPOUNDMENT
	COX RESERVOIR

WATER BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)	POPULATION
1	TRIBUTARY TO OTTAWA RIVER	WEST WOODSTOCK	2	100

TYPE OF DAM	YEAR COMPLETED	PURPOSES	SPILLWAY HEIGHT (FT.)	HYDRAULIC HEIGHT (FT.)	IMPOUNDING CAPACITIES		DIST DWN FED R	PRV/FED	SCS A	VER/DA
					MAXIMUM (ACR.-FT.)	NORMAL (ACR.-FT.)				
2	1930	S	25	25	21	18	NED	N	N	N

REMARKS

D/S HAS	SPILLWAY LENGTH	TYPE	WIDTH	MAXIMUM DISCHARGE (FT.)	VOLUME OF DAM (CY)	POWER CAPACITY		NAVIGATION LOCKS											
						INSTALLED	PROPOSED	NO.	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH	WIDTH					
2	145	U	M	200	4430														

OWNER	ENGINEERING BY	CONSTRUCTION BY
WINDHAM AVIADUCT CO		

REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	NONE

INSPECTION BY	INSPECTION DATE	AUTHORITY FOR INSPECTION
MURRAY NEEDLES TAMMEN BERGENDOFF	12 SEP 79	PL92-367

REMARKS

DATE
FILMED
-8